1 Introduction
A human-factors experiment has examined the effects of different sorts of technical anomalies, or breaks in presence, on user experience. Four different types of anomaly were investigated in an order-balanced experiment over two game types (combat and navigation). A population of 20 volunteer participants was divided into two groups according to which game type they played first. After each game, participants were asked to rate the impact of the anomalies on their feelings of presence in the game experience and also of their effect on the recovery time. There is tentative evidence that the impact of breaks in presence were greater in the combat mode of game playing. The recovery time from breaks in presence depends on types of anomaly whereas it is independent of game type and the order of game experience. In addition, the impact and the recovery time from each anomaly were not quantitatively correlated with each other.

2 Presence
2.1 Game and presence
One of the markers of modern life is the ubiquity of video games as a familiar form of entertainment. With the latest technological advances, video games are metamorphosing from simple shoot-them-up games into complex psychological experiences in which many gamers compete and collaborate. Designing these complex experiences to be enjoyable and absorbing entertainment is an ultimate goal of game developers. In their study of increasingly sophisticated video games, researchers have investigated how the virtual reality concept of “being there” or “presence” can be utilized to enhance the player experience. Numerous studies have examined the various influences on the feeling of presence and some of the well-known factors are frame rate, field of view, sound, latency and control.

2.2 Breaks in presence
During game playing, a player is likely to experience various unexpected impediments or distractions which are known to degrade the feeling of presence. Such distortions or anomalies have been termed breaks in presence (BIP) by Slater et al who have used these to study the nature of the presence experience. Furthermore, these authors have examined an association between a dramatic BIP (a screen whiteout) and physiological responses including skin conductance and heart rate. In a companion paper they also suggested that BIPs could have multiple causes and different intensities which would result in varying recovery times.

3 Methods

3.1 Experiment description
Participants were made up of 20 male undergraduate and postgraduate students with a mean age of 23 years (standard deviation of 3.5). The experiment was conducted in a virtual reality theater with two, rear-projected, 2.9m x 2.2m screens, joined at an angle of 90 degrees and providing an almost 180 degree immersive field of view (see Fig. 1(a)).

3.2 Game environment
For this research, we used a first person shooter (FPS) game which was originally written for a study of a commercial, online, 3D, game engine. In our experiment, participants played two game modes: navigation and combat. In navigation mode, there was no particular mission and no threat of attack. Participants were told that they should explore the environment which was the interior of a two-story building including a grand staircase and balcony all with medieval decor. Players had use of their weapon in this mode, and they could amuse themselves by taking shots at stationary enemy avatars which were scattered through the building but which would not retaliate. In combat mode, participants were subject to continuous attack by enemies and they needed to engage in typical FPS tactics such as moving quickly, shooting, hiding and so on. The enemy avatars were under the control of a remote participant who was an experienced player of this game level and who tuned the intensity of their attack to be always just at, or above, the level of competence of the player.

3.3 BIP design
In order to investigate participants’ subjective feeling of breaks in presence during game play, we induced four technical anomalies: low frame rate, sound absence, reverse control and screen black-out. Their details, and nomenclature, are given in Table 1.

3.4 Experiment description
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Table 1: Breaks in Presence used in the experiment.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>BIP1</td>
<td>Low frame rate</td>
</tr>
<tr>
<td>BIP2</td>
<td>Sound absence</td>
</tr>
<tr>
<td>BIP3</td>
<td>Reverse control</td>
</tr>
<tr>
<td>BIP4</td>
<td>Screen black out</td>
</tr>
</tbody>
</table>

4 Results

4.1 Analysis
By partitioning the data in Table 2 and from examination of the corresponding box-plots (not shown here) we focused our qualitative and quantitative analysis on three questions: Does the type of game experience make a difference? Does the ordering of the game experience make a difference? Does the type of BIP make a difference?

The effects of game type are read from the table by comparing N1C2 (navigation with C1N2 (combat) for the first presence and C1N2 (navigation) with N1C2 (combat) for the second experience. Only the results for the second experience show a clear trend across all BIPs and this is that BIPs in combat mode have higher impact. The Mann-Whitney U test (for between groups) showed that this result was statistically significant at the 0.05 level (ignoring Bonferroni corrections) for BIPs 2, 3, and 4. The main effect of first experience versus second experience (independent of game type, and paired across participants and BIPs) show a slight qualitative trend which is dominated by comparing N1C2 (navigation) with N1C2 (combat). This trend is that the second experience has higher impact. Although the observation for N1C2 in isolation is confounded by the effects of game type (the effect of the previous paragraph), the trend for C1N2 across game gives further evidence: This trend is much weaker which might be due to game order balancing game type. The Wilcoxon matched pairs test was used for this analysis and was dominated by the results for BIPs 1 and 2 for N1C2 (whose results in isolation are significant at the 0.05 level ignoring the Bonferroni correction).

Furthermore, effects of BIP type can be read from the rows of table. Qualitative trends are observed for BIP2 in the impact (lower impact than other BIPs) and BIP3 in recovery (higher recovery figures than other BIPs). The last BIP result is the only result of interest from the recovery table - all other comparisons wash out in spite of some clear trends in the impact table. That is, recovery seems to depend (slightly) on BIP but be independent of game type and the order of the game experience. The data also indicate that the recovery time and the impact of each anomaly were not quantitatively correlated with each other.

Table 2: Medians and inter-quartile ranges for Question 1 and 2

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5 Conclusion
The study reported here investigated how participants experienced intentional technical anomalies during game playing. From the survey data, there is some evidence to support the idea that “violent” (or combat) game playing is more susceptible to breaks in presence. There is tentative evidence that two of the breaks in presence affected participants in different ways (BIP2 with less impact, BIP3 with more recovery time) than the others. Some weak order effects were observed, but these were dominated by the group of participants who experienced the navigation experience first. The recovery time was independent of game type, order of the game and the impact of each anomaly. There were some limitations in our experiment. The level setting of BIP1 (degrading to 5Hz) was set arbitrarily. The duration of all BIPs was set to an arbitrary value.

The analysis is presently underway of a large amount of secondary data obtained from video-cued walkthroughs of each game experience. The results of this analysis will eventually be compared with the survey data presented here. Future experiments will attempt to provide more substantial evidence and understanding of the tentative results described here as well as examining the effects of some of the other breaks in presence events notes by participants in this study.

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Figure 1: (a)View of the “Wedge” theater (b)Game screen shot in combat mode.

Figure 2: Breaks in Presence used in the experiment.